PATENT ABSTRACTS OF JAPAN

(11)Publication number : 11-086032
(43)Date of publication of application : 30.03.1999

(51)Int.Cl. G06T 17/00

(21)Application number : 09-236191
(22)Date of filing : 01.09.1997

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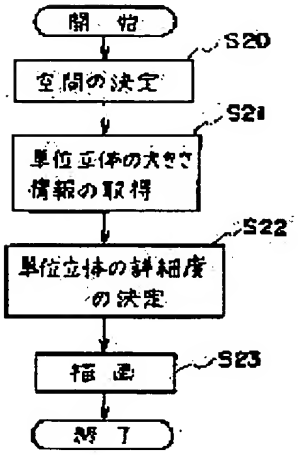
(54) SPATIAL DRAWING PROCESSING METHOD

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a spatial drawing processing method capable of easily adopting a detail degree model, which is suitable when models are switched in LOD management of CAD and CG.
SOLUTION: A space to be drawn is determined (S20). Information on the size of a unit solid such as an object included in the space is obtained (S21). The size distribution, therefore, unit solids are grouped and a model having a large detail degree is adopted even if a viewpoint distance becomes larger for a larger unit solid. A small unit solid is speedily switched to a model having a small detail degree as the viewpoint distance increases (S22).



LEGAL STATUS

[Date of request for examination]	03.12.1997
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3151171
[Date of registration]	19.01.2001
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

[Claim(s)]

[Claim 1] A space drawing art characterized by determining whenever [details / at the time of appointing space which should draw, acquiring information about magnitude of each unit solid contained in the space, and drawing each unit solid according to the information].

[Claim 2] A space drawing art to which two or more models with which whenever [details] differ about each unit solid are prepared for in a method according to claim 1, and a bigger unit solid draws using a high model of whenever [details] relatively.

[Claim 3] A space drawing art from which distance from a view changes it to a low model of whenever [details] relative early in a method according to claim 2 as a smaller unit solid becomes large.

[Claim 4] A space drawing art which searches for distribution of magnitude of an unit solid contained in either of claims 2 and 3 in a method of a publication in space, and chooses a model of each unit solid in consideration of the distribution.

[Claim 5] different space in a method according to claim 4 -- said distribution -- respectively -- asking -- ******** -- a space drawing art which chooses a model of each unit solid about each space so that a load of a computer may be equalized to some extent, in case space is drawn.

[Claim 6] A space drawing art characterized by appointing space which should draw, setting up whenever [details / of a big unit solid] more highly among unit solids contained in the space, and setting up whenever [details / of the other unit solid] low as it becomes small.

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention relates to a space drawing art and the method of drawing that whole space by drawing the unit solid contained especially in space.

[0002]

[Description of the Prior Art] In the world of computer graphics (CG), processing which draws many unit solids according to a user's view is often performed. An object is in the example of an unit solid. For example, the space which a user should draw first is specified to create the walk-through image in a factory. Polygon data of an object, such as equipment and a device, is read continuously, and space is drawn. The minute expression of various space is attained by CG, and the expectation for a user's CG is growing further. Demand of wanting to draw more objects on a high speed more at a precision does not cease. Although computer power was extended rapidly recently, it is not easy to meet all such demands.

[0003] There is the management technique called LOD (Levels Of Detail) to one of the technique which has moderate rapidity and performs precise drawing. LOD should call it also whenever [details / in the case of drawing], and prepares two or more models with which whenever [details] differ for every unit solid beforehand. If the space which should draw is decided, about the unit solid near a view, space will be drawn more highly [whenever / details] that is, using the model which whenever [details] is low about a far thing, that is, was simplified more in the minuter model. Since a nearer thing influences the subjectivity quality of an image, while drawing a near thing on a precision, it accelerates processing by drawing a far thing somewhat rough. LOD has a publication in Chapter 7.4.3 of "Flight Simulation" (edited by J.M.Rolfe and Kj.Staples Cambridge University Press).

[0004]

[Problem(s) to be Solved by the Invention] However, in the case of the conventional LOD management technique, which model was used for which unit solid in which scene, or there were not much clear criteria. Therefore, while the whole space was drawn on details too much, the processing time was prolonged or there was additional coverage in the processing time at reverse, a feeling of unification might be lacked in processings -- adopt the low model of whenever [details] too much, and the whole image quality falls off. Moreover, even if it used only the low models of whenever [details] and drew space, when an unit solid recognized a large number existence extremely, the limit was in improvement in the speed of processing too.

[0005] This invention is made in view of such a technical problem, and the purpose is in offering the space drawing art which can adopt a model easily whenever [suitable about each unit solid details].

[0006]

[Means for Solving the Problem] A space drawing art of this invention appoints space which should draw first, and acquires information about magnitude of each unit solid contained in the space. Next, whenever [details / at the time of drawing each unit solid

according to the information] is determined. At this time, two or more models with which whenever [details] differ beforehand about each unit solid may be prepared, and a bigger unit solid may draw using a high model of whenever [details] relatively. Moreover, distance (henceforth view distance) from a view may change it to a low model of whenever [details] relative early as a smaller unit solid becomes large. According to this method, compaction of the processing times, such as count, is realizable, maintaining subjectivity image quality highly.

[0007] In this invention, distribution of magnitude of an unit solid contained in space may be searched for, and a model of each unit solid may be chosen in consideration of the distribution. By taking distribution into consideration, the situation where only low models are intensively chosen about a high model of whenever [details] or as reverse can be avoided, and model selection is rationalized.

[0008] moreover -- different space at this time -- said distribution -- respectively -- asking -- ******** -- in case space is drawn, a model of each unit solid may be chosen about each space so that a load of a computer may be equalized to some extent. By this, even if space changes, a load of a computer becomes homogeneity to some extent, and it is convenient to equalization of the processing time.

[0009] In another mode of this invention, space which should draw first is appointed and whenever [details / of a big unit solid] is more highly set up among unit solids contained in the space in a viewpoint of volume (three dimensions), length (single dimension), or area (two dimensions). Moreover, whenever [details / of the other unit solid] is low set up as it becomes small. By this setting method, people's per eye and a cone unit solid can be drawn minutely, and subjectivity image quality can be maintained highly. On the other hand, the amount of data about a small unit solid of effect in subjectivity image quality becomes less, and the processing time becomes short. In addition, if it says "It is "large" and small" on these specifications, it should be interpreted as a thing including a viewpoint of length besides volume, or area.

[0010]

[Embodiment of the Invention] The gestalt of suitable operation of this invention is explained referring to a drawing suitably.

[0011] Gestalt 1. drawing 1 of operation is a flow chart which shows the preparation procedure of the space drawing art concerning the gestalt 1 of operation. As shown in this drawing, two or more models with which whenever [details] differ about each unit solid are created (S1). For example, most, the high model (this is called M0 below) of whenever [details] may be the CAD data of that unit solid itself, and the number of polygons becomes the most numerous with this model.

[0012] next, the high model (this is called M1 below) of whenever [details] is created by

methods of having reduced the number of polygons under the regulation of arbitration from M0, such as being a model, for example, transposing solid [some] to a simple primitive (radical bookstand objects, such as a cube, a rectangular parallelepiped, a pyramid, and a cone), or replacing an unit solid in a circumscription rectangular parallelepiped simply. [unifying a neighboring polygon] M1, M2, --, Mn are created towards whenever [details] falling about each unit solid like the following. For example, about a certain unit solid, 1000 polygons and M1 make it as 400 polygons, and M2 makes M0 100 polygons etc. Henceforth, since it is easy, n= 2 explains.

[0013] In addition, an object is sufficient as an "unit solid" and a solid small to the pan which constitutes an object is sufficient as it here. That is, unit solids should just be the unit of processing, especially the unit of drawing processing. Usually, since the small solid (henceforth an element solid) based on a primitive etc. is used in the process which generates the data of an object on CAD, it is good also considering this element solid as an unit solid. Drawing 2 shows the relation of the element solid which constitutes one object and it. Here, an object is a bolt and this consists of a total of four element solids, the hexagon-head drill of the summit section, the hexagonal prism under it, the cylinder of the idiosoma under it, and the hexagon-head drill of a pars basilaris ossis occipitalis. What is necessary is just to generate two or more models for every object and every element solid with the gestalt 1 of operation. Anyway, it is the purpose to introduce a statistical procedure into selection of a model whenever [details] according to the magnitude of an unit solid.

[0014] Drawing 3 is a flow chart which shows the procedure of the space drawing art concerning the gestalt 1 of operation. As shown in this drawing, the space (only henceforth space) which should draw by the known method first is determined (S20). It continues and the information about the magnitude of each unit solid contained in the space is acquired (S21). Magnitude has and judges various geometric-like numeric values, such as capacity of an unit solid, capacity of the circumscription rectangular parallelepiped of an unit solid, the length of the longitudinal direction of an unit solid, and surface area of an unit solid. As an easy example, how to register the capacity of a circumscription rectangular parallelepiped for every unit solid beforehand can be considered. In that case, required information is acquirable by reading the capacity registered about each unit solid contained in space. Drawing 4 is the distribution map which was obtained by processing of S21 and in which showing the magnitude and the frequency of the unit solid contained in a certain space. Here, the minimum magnitude considered as an unit solid is normalized to 1. This space is actual distribution when expecting the both-arms mold manipulator which consists of about 220 object, and there are many unit solids of the magnitude of 104-107 here.

[0015] It continues and whenever [details / of each unit solid] is determined based on distribution of the magnitude of an unit solid (S22). Drawing 5 shows the condition that plurality carried out group G0-Gn division of the unit solid of drawing 4 according to the magnitude. Here, it is n= 5 as an example and G0 asks the group of max [magnitude / of an unit solid]. Although it divided in this drawing so that the number of the unit solids contained in each group might become almost equal, an unit solid's existence range may be divided at equal intervals. An important thing is in the point which optimizes grouping by dividing a group for every space, if distribution differs at all for every space. Namely, when all unit solids are 103 or less magnitude, for example, a group G0 is taken to the 103 neighborhoods, and even if the situation of distribution is different, Groups G0-Gn are appropriately set for every space. On the other hand, drawing 6 is drawing showing an example of the model Mj chosen about each group Gi according to the view distance D. In this drawing, it is written as d0, d1, --d7 in the order near a view. As shown in this drawing, even if view distance becomes large, the always most detailed model M0 is chosen about the group G0 of the biggest unit solid that is the easiest to attach to the public notice. On the other hand, less than [G1] and a smaller unit solid are changed to the low model of whenever [details] relative early as view distance becomes large, and the amount of data and the processing times are reduced. For this reason, in S22, the range of the view distance which adopts the high model of whenever [details] about a first big unit solid may be decided, and you may consider henceforth that a gradually small unit solid determines whenever [details / of a model], and may put it in another way as normalizing space by the big unit solid.

[0016] Drawing 7 is drawing showing other examples of the model Mj chosen about each group Gi according to the view distance D. In this drawing, about the for example smallest group G5, as for a model M0, it is adopted only at the time of distance d0, and, as for a model M1, is adopted only at the time of distance d1, and a model M2 is used henceforth. About group G3 small to the 3rd, a model M1 is adopted for a model M0 at the time of distance d3 and d4 at the time of distance d0-d2. That is, the model about a smaller unit solid is changed to earlier timing. It is for the effect to subjectivity image quality to fade rapidly as a smaller unit solid keeps away from a view.

[0017] Drawing 8 is drawing showing the example of further others of the model Mj chosen about each group Gi according to the view distance D. Although this drawing is close to drawing 6 , as "-" shows among drawing, the points which choose the imagination model of un-displaying differ about the small groups G4 and G5. That is, about the portion shown by "-", the unit solid contained in the corresponding group is not displayed at all. Even if it displays the 1cm carbon button of dozens of meters beyond and does not carry out it, it uses for subjectivity image quality the rule of thumb

of hardly influencing in many cases. In addition, it is good about a group G5 also as "un-displaying" etc. after a model M0 and distance d1 only at the time of distance d0, for example. In that case, about a group G5, even the time and effort which generates the model with which whenever [details] differ is saved. As a model M0, it is ********** about the CAD data of a basis.

[0018] In this way, if whenever [details / of each unit solid] is decided by S22, it will draw based on each model (S23). By the above, the objective LOD management technique in which the magnitude of an unit solid was taken into consideration is realized.

[0019] With the gestalt 1 of gestalt 2. implementation of operation, the relation of whenever [view distance and details] was defined based on the magnitude of an unit solid, and the relation of a number. With the gestalt 2 of operation, the relation of whenever [view distance and details] is defined from the magnitude of an unit solid, and the relation of a count load. With the gestalt 2 of operation, whenever [details] shall be decided that the total number of polygons which should draw about different space becomes almost equal.

[0020] Drawing 9 is a flow chart which shows the preparation procedure of the gestalt 2 of operation. As shown in this drawing, a model is first created whenever [each details] about all unit solids like S1 of drawing 1 (S30).

[0021] Next, some typical space is selected as a sample among the space of **** set as the object of drawing, and these are named the s-th space (s= 1, 2 --). For example, although the space which should draw may exist innumerably, uses, such as a walk-through simulation, are sufficient if the space of a finite individual is selected here. Then, when the selected space is entirely drawn without an abbreviation, the total number of polygons contained in each space is computed for every space (namely, when all the unit solids contained in that space are drawn by CAD data) (S31), and this is recorded. It writes Ns [the total number of polygons contained in the s-th space in case there is no abbreviation] (s= 1, 2 --). Preparation is completed above.

[0022] Drawing 10 is a flow chart which shows the procedure of the gestalt 2 of operation. The same sign is given to the same step as drawing 3 in this drawing, and it explains focusing on a different step from drawing 3 .

[0023] The space which should draw by S20 of this drawing first is decided. Since space is decided about the view of arbitration, generally the point which is not included in the s-th space (s= 1, 2 --) taken into consideration by drawing 9 takes cautions to this space. Then, distribution of the magnitude of each unit solid of the space which should draw by S21 becomes clear.

[0024] It continues and the magnitude of an unit solid and the relation of a count load

are drawn by S40. In order to think that a count load is proportional to the number of polygons mostly, the number of polygons of the unit solid corresponding to a horizontal axis and each magnitude for the magnitude of an unit solid is taken along an axis of ordinate. Drawing 11 is the distribution map obtained in this way. In the case of this drawing, the number of polygons about the biggest unit solid has become a little less than 4000, but this is those numbers of sum total polygons, when two or more unit solids of the magnitude exist. It asks also for the total number Nx of polygons contained in this space in case there is no abbreviation in S40.

[0025] Next, the number of aim polygons is set up by S41. In case the number of aim polygons draws space, it is the desired value of the number of polygons which should draw to the space. Now, temporarily, the walk-through simulation from a certain point to another point is the purpose, and suppose that the space decided by S20 is also on the path. Moreover, suppose that three of two or more s-th space (s= 1, 2 --) taken into consideration by drawing 9 , the 1st space, the 5th space, and the 10th space, are contained on this path. The number Nt of aim polygons is then set up for example, by the degree type.

[0026]

Nt=k-min (N1, N5, N10) (0< k<=1) (formula 1)

However, min (a, b, c--) is the minimum value of a, b, and c--.

[0027] Next the total number Nx of polygons of the space which is going to draw now is reduced, and whenever [details / of each unit solid] is decided to bring close to the number Nt of aim polygons (S42). For this reason, like drawing 5 of the gestalt 1 of operation, grouping of the unit solid is carried out according to magnitude. If selection of whenever [details] follows drawing 6 about this space now, in S42, the initial valve position of the boundary line which divides a group first is assumed, a model is selected according to drawing 6 , and the total number of polygons in case there is an abbreviation is calculated. The total number of polygons in case there is an abbreviation is calculated serially, shifting every and carrying out a little location of a boundary line next, and, finally the location of a boundary line when this numeric value approaches Nt most is adopted. What is necessary is just to perform such grouping, whenever space changes. Moreover, about the space which once performed grouping, next drawing is accelerable by saving the result of the grouping.

[0028] The above is the procedure of the gestalt 2 of operation. Since according to the gestalt of this operation the count load for drawing that space is mostly equalized even if space changes, the estimate of computation time required for drawing becomes certain. Therefore, the certainty which draws each space on real time increases also for a use which draws various space one after another. What is necessary is just to make

the value of k of a formula 1 small, when setting weight to compaction of the processing time. If the maximum Nu of the number of polygons for real-time operation implementation becomes clear conversely from the engine performance of a computer, grouping can also be carried out so that it may become Nt<=Nu. That is, it is the view which holds down the total number of polygons to below a predetermined value about each space.

[0029] With the gestalt 2 of gestalt 3. implementation of operation, the concept of the number Nt of aim polygons was introduced. With the gestalt of this operation, taking a count load into consideration like the gestalt 2 of operation, rather than the gestalt 2 of operation, there are few man days and they explain the high space drawing art of versatility.

[0030] The gestalt 3 of operation uses the gestalt 1 of operation as the base. However, not only the magnitude of an unit solid but the number of polygons is considered. The flow of processing is the same as that of the gestalt 1 of operation almost, and is different only in respect of the following.

[0031] 1. Acquire not only the magnitude of an unit solid but the information about the number of polygons collectively in S21 of drawing 3 .

2. Derive drawing 11 instead of drawing 4 in consideration of the number of polygons. Grouping is performed by the same method as moreover having drawn drawing 5 from drawing 4 . That is, with the gestalt of this operation, Group Gi is set that the number of sum total polygons of the unit solid belonging to each group becomes almost equal.

[0032] As mentioned above, according to the gestalt of this operation, processing is accelerable like the gestalt 1 of operation, maintaining subjectivity image quality. Furthermore, in addition to the gestalt 1 of operation, the effect of equalization of a processing load can be acquired.

[Brief Description of the Drawings]

[Drawing 1] It is the flow chart which shows the preparation procedure of the space drawing art concerning the gestalt 1 of operation.

[Drawing 2] It is drawing showing the relation of the element solid which constitutes one object and it.

[Drawing 3] It is the flow chart which shows the procedure of the space drawing art concerning the gestalt 1 of operation.

[Drawing 4] It is the distribution map showing the magnitude of an unit solid and the relation of frequency which are included in a certain space based on the result of one gestaltS21 of operation.

[Drawing 5] In one gestaltS22 of operation, it is drawing showing the condition of

having divided the unit solid of drawing 4 into two or more groups according to the magnitude.

[Drawing 6] In one gestaltS22 of operation, it is drawing showing an example of the model Mj chosen about each group Gi according to view distance.

[Drawing 7] In one gestaltS22 of operation, it is drawing showing other examples of the model Mj chosen about each group Gi according to view distance.

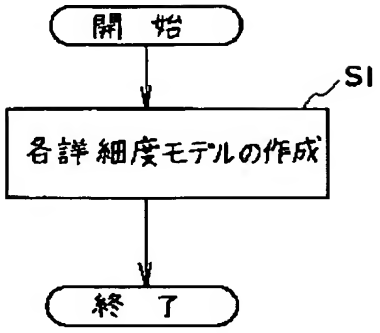
[Drawing 8] In one gestaltS22 of operation, it is drawing showing the example of further others of the model Mj chosen about each group Gi according to view distance.

[Drawing 9] It is the flow chart which shows the preparation procedure of the gestalt 2 of operation.

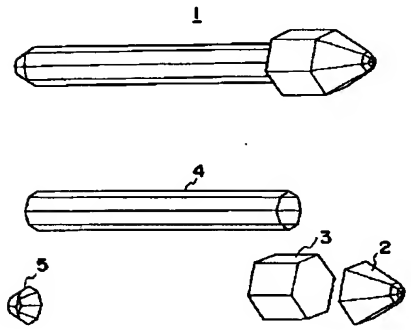
[Drawing 10] It is the flow chart which shows the procedure of the gestalt 2 of operation.

[Drawing 11] It is the distribution map showing the magnitude of the unit solid contained in a certain space, and the relation of the number of sum total polygons of the unit solid corresponding to each magnitude based on the result of two gestaltS40 of operation.

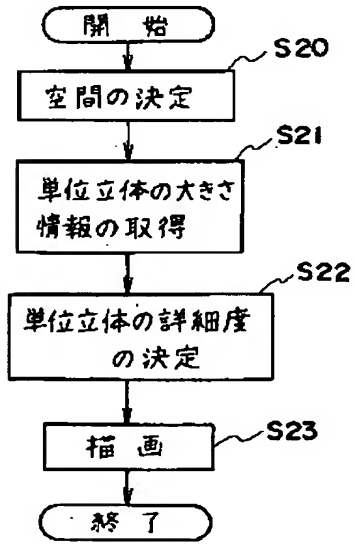
[Drawing 1]



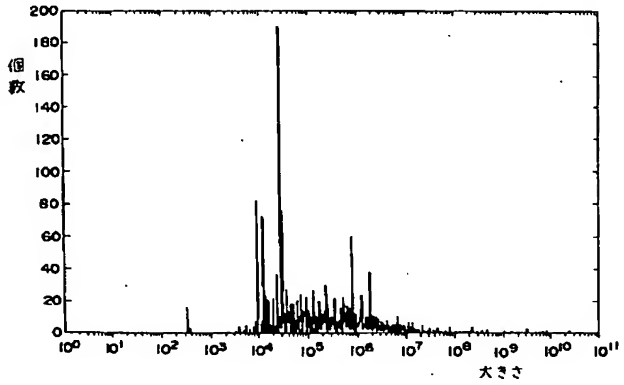
[Drawing 2]



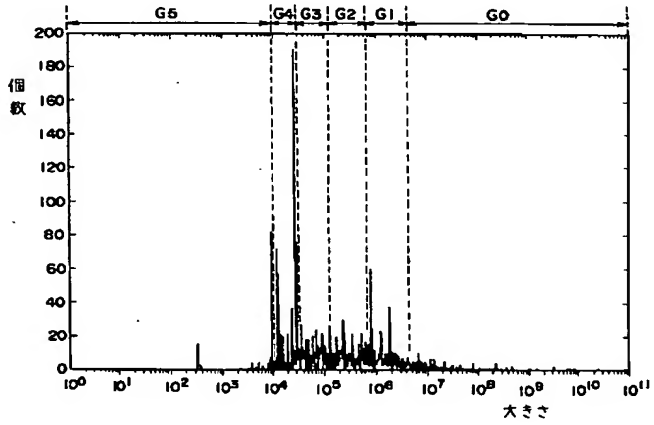
[Drawing 3]



[Drawing 4]



[Drawing 5]



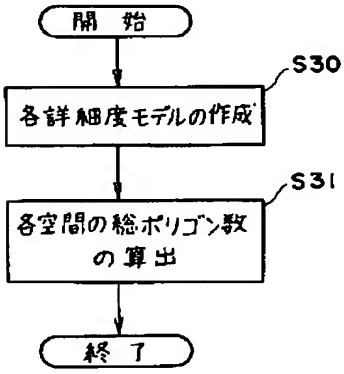
[Drawing 6]

G \ D	d0	d1	d2	d3	d4	d5	d6	d7
G5	M0	M1	M1	M2	M2	M2	M2	M2
G4	M0	M0	M1	M1	M2	M2	M2	M2
G3	M0	M0	M0	M1	M1	M2	M2	M2
G2	M0	M0	M0	M0	M1	M1	M1	M2
G1	M0	M0	M0	M0	M0	M0	M1	M1
G0	M0	M0	M0	M0	M0	M0	M0	M0

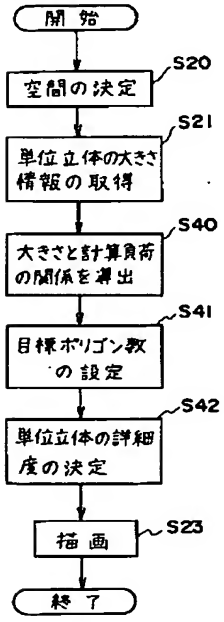
[Drawing 7]

G \ D	d0	d1	d2	d3	d4	d5	d6	d7
G5	M0	M1	M2	M2	M2	M2	M2	M2
G4	M0	M0	M1	M2	M2	M2	M2	M2
G3	M0	M0	M0	M1	M1	M2	M2	M2
G2	M0	M0	M0	M0	M1	M1	M1	M2
G1	M0	M0	M0	M0	M0	M1	M1	M1
G0	M0	M0	M0	M0	M0	M0	M1	M1

[Drawing 9]



[Drawing 10]



[Drawing 8]

G \ D	d_0	d_1	d_2	d_3	d_4	d_5	d_6	d_7
G5	M0	M1	M1	M2	M2	—	—	—
G4	M0	M0	M1	M1	M2	M2	—	—
G3	M0	M0	M0	M1	M1	M2	M2	—
G2	M0	M0	M0	M0	M1	M1	M2	M2
G1	M0	M0	M0	M0	M0	M1	M1	M2
G0	M0	M0	M0	M0	M0	M0	M1	M1

[Drawing 11]

G \ D	d_0	d_1	d_2	d_3	d_4	d_5	d_6	d_7
G5	M0	M1	M1	M2	M2	—	—	—
G4	M0	M0	M1	M1	M2	M2	—	—
G3	M0	M0	M0	M1	M1	M2	M2	—
G2	M0	M0	M0	M0	M1	M1	M2	M2
G1	M0	M0	M0	M0	M0	M1	M1	M2
G0	M0	M0	M0	M0	M0	M0	M1	M1